Safety Evaluation of Corner Clearance at Signalized Intersections

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ABSTRACT
This study evaluates corner clearance at signalized intersections under the Development of Crash Modification Factors program for the Evaluation of Low Cost Safety Improvements Pooled Fund Study. Geometric, traffic, and crash data were obtained for signalized intersections with various corner clearances from California and Charlotte, North Carolina. A cross-sectional analysis was conducted to estimate the effects of corner clearance while controlling for other differences among study sites. The estimated CMFs indicated that more limited clearance on receiving corners (i.e., driveway(s) within 50 ft of the signalized intersection) was associated with increases for all crash types, based on the data included in this analysis. These increases were statistically significant at the 90 percent level or greater for total, fatal and injury, rear-end, sideswipe, right-angle, and nighttime crashes. Only the results for turning crashes were not statistically significant at the 90 percent level. For limited corner clearance on the approach corners, the results indicated statistically significant reductions in total, fatal and injury, and rear-end crashes. The results also indicated reductions in sideswipe and nighttime crashes, and increases in right-angle and turning crashes, but none of these results was statistically significant at the 90 percent level.

INTRODUCTION

Corner clearance is defined as the distance between an intersection and the nearest driveway or access point along the approach. Adequate corner clearance is an important factor in the safety and operations at intersections. AASHTO's *A Policy on Geometric Design of Highways and Streets* (also known as "The Green Book") notes that driveways should not be located within the functional area of an at-grade intersection or in the influence area of an adjacent driveway.(1) However, the presence of conflicting driveways within the functional area is often unavoidable, especially in urban environments. Limited corner clearance, or the presence of driveways in close proximity to intersections, is suspected to have negative effects on operational efficiency, capacity, and safety due to driveway turning movements conflicting with vehicles at the larger intersection.

While inadequate corner clearance is a concern for all types of intersections, signalized intersections develop recurring queues within the functional area of the intersection that can lead to conflicts with vehicles turning in and out of driveways. Approaches to signalized intersections also have more lanes on average than other types of at-grade intersections, which can cause difficulties for drivers leaving driveways to weave and maneuver into their desired lanes.

States have proposed access management strategies to balance the safety and operational efficiency of intersections while maintaining access to properties along, and adjacent to, the roadway. Inadequate corner clearance is often a reason why access management strategies are proposed at intersections during safety reviews. However, there is limited information available about the quantitative safety effects of corner clearances. This study serves to address the need for research into the safety effects of corner clearances on the mainline approach and receiving corners at four-leg, signalized intersections. Figure 1 shows a general layout of a study site in this evaluation, illustrating the measurement of corner clearance and defining mainline approach and receiving corners.

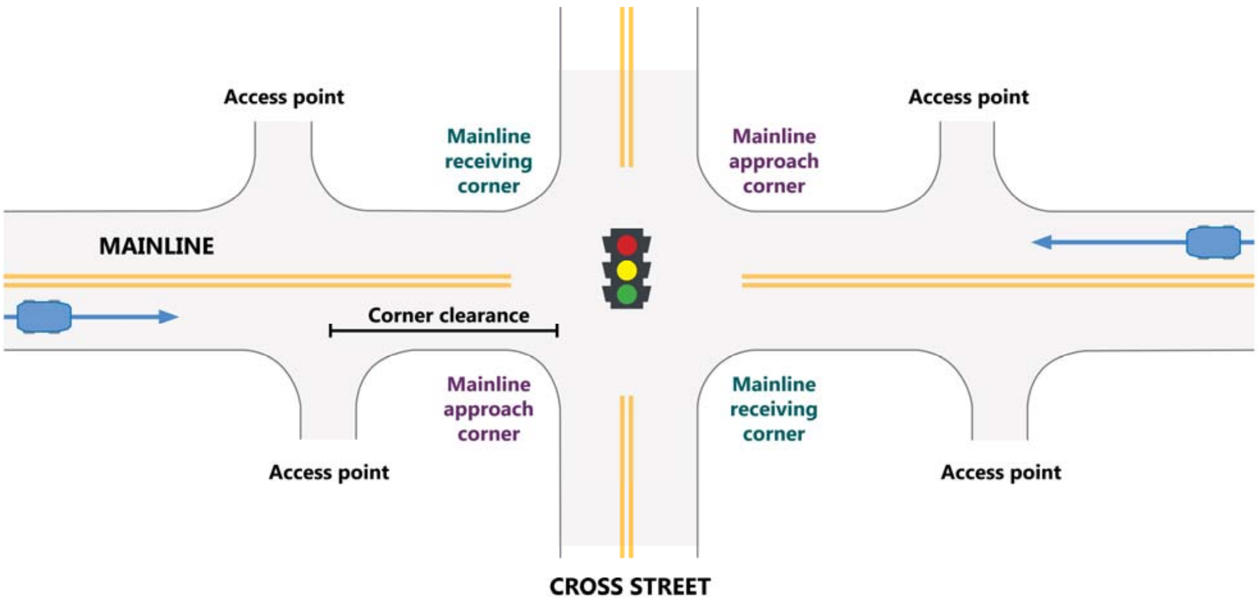

Figure 1. General layout of study site.

LITERATURE REVIEW

Most corner clearance-related evaluations to date have focused on corridor safety effects rather than intersection safety. The research team found only one study that examined corner clearance at intersection level. In this study, Kwigizile et al. examined changes in the number of crashes at urban signalized intersections as a result of corner clearance and other variables.(2) A zero-inflated negative binomial model was selected from four model forms as the best model for determining the safety effects of the treatment. The authors modeled corner clearance as the number of corner clearances (i.e., number of access points) and the average corner clearance in feet, with a maximum of 250 ft. The results indicated that increased corner clearance and fewer access points yielded fewer crashes. Commercial driveways with limited corner clearance led to higher crash rates than residential access. Signals with higher minor road volumes had a higher number of crashes. Crashes generally increased with the addition of left-turn lanes and through lanes, with through lanes leading to a greater increase.

RESEARCH OBJECTIVE

The objective of this research is to examine the safety effects of various corner clearances at signalized intersections in State of California and City of Charlotte, North Carolina measured by changes in crash frequency. Target crash types included the following:

- Total: all crashes within 250 ft of intersection (all types and severities combined).
- Fatal & Injury: all injury crashes within 250 ft of intersection (K, A, B, and C injuries on KABCO scale).
- Rear-end: all crashes within 250 ft of intersection and the accident type coded as rear-end.

- Sideswipe: all crashes within 250 ft of intersection and the accident type coded as sideswipe.
- Right-angle: all crashes within 250 ft of intersection and the accident type coded as broadside or angle.
- Right- and left-turn: all crashes within 250 ft of intersection and the driver's action prior to collision coded as turning right or turning left.
- Nighttime: all crashes within 250 ft of intersection and light condition coded as dusk, dark and dawn.

A further objective was to address the following questions:

- Do effects vary by level of traffic volume on major and minor routes?
- Do effects vary by lane configuration of major and minor routes?
- Do effects vary by posted speed limit on the major route?
- Do effects vary by median presence on the major route?
- Do effects vary by presence of turning lanes on major route?

The evaluation of overall effectiveness included the consideration of the removal of driveway costs and crash savings in terms of the benefit-cost ratio.

METHODOLOGY

The evaluation used a cross-sectional study design. At the most basic level, the safety effect is estimated by taking the ratio of the average crash frequency for two groups, one with the treatment and the other without the treatment. The two groups of sites should be similar in all regards except for the presence of the treatment. This is difficult to accomplish in practice, and the project team used propensity score matching to match sites with and without treatment, and used multivariable regression modeling to control for other characteristics that vary among sites.

The project team used multivariable, negative binomial regression to develop the statistical relationships between the dependent variables and a set of predictor variables. In this case, crash frequency was the dependent variable, and the team considered predictor variables, including treatment presence, traffic volume, and other roadway characteristics. The team estimated regression coefficients during the modeling process for each predictor variable. The coefficients represent the expected change in crash frequency due to a unit change in the predictor variable with all else being equal. One concern was the possibility of site-selection bias if agencies installed turning movement restrictions to address safety issues. The project team used propensity score matching to address potential site selection bias. Detailed discussions of propensity score matching and its application in traffic safety research are available in papers by Rosenbaum and Rubin (1983) and Sasidharan and Donnell (2013).[5,6]

DATA COLLECTION

The analysis and discussions presented in this study relied on two data sets: California and Charlotte, North Carolina. The original plan was to collect data from California with geographical representation from both the northern and southern regions of the State. After the preliminary analysis of California data, the FHWA approved another effort to collect additional data from Charlotte, North Carolina. The data sources for these two study areas differed in many ways and required the research team to develop separate data collection methods for each dataset. The following sections discuss the details of data collection efforts.

The California data for this study came from the following two separate sources:

- *Prior FHWA Study*. The research team obtained corner clearance, key geometric features, and operational characteristics from a Geographic Information System (GIS) database developed under a previous FHWA-funded project entitled *Safety Evaluation of Access Management Policies and Techniques*.(7)

Highway Safety Information System (HSIS). The research team obtained intersection, roadway, and 3 years (2009-2011) of traffic and crash data from the HSIS database.

The data for Charlotte, North Carolina came from the following two sources:

- *HSIS.* The research team obtained intersection, traffic, and crash data files from HSIS. The data came in GIS shape files that allowed the research team to employ various spatial analysis tools in GIS to process the data. The GIS data also provided intersection location information for data collection from Google Earth™.
- *Google Earth*™: The research team obtained corner clearance, intersection configuration, number of lanes, driveway density, and the general characteristics of the corridor on which the intersection is located from Google Earth™ using satellite imagery, Street View images, and measuring tools.

It is recommended that the readers refer to the full report (to be published through the FHWA) for detailed discussions of the tools and techniques used, as well as the data collection procedures for each dataset.

Data Characteristics and Summary

The research team collected and aggregated 3 years of data for the analysis. Table 1 presents the summary of the final dataset with 275 signalized intersections included in the analysis. Indicator variables are either 0 or 1, indicating the absence or presence of the characteristic, respectively. The mean value of an indicator variable represents the proportion of sites for which the indicator is 1. For example, the indicator for 50 mph or higher posted speed on the mainline in Table 1 has a mean value of 0.44. This implies that 44 percent of locations have a posted speed of 50 mph or higher (indicator value = 1) and 56 percent of locations have posted speed of less than 50 mph (indicator value = 0). It is worth noting that there are overlaps between turning crashes and other crash types (e.g., a rear-end crash can be related to a turning maneuver so it was also coded as a turning crash).

Table 1. Data summary for signalized intersections and corner clearance.

Description	Mean	Min	Max
Number of total crashes (crashes/3 years)	13.4	0	166
Number of fatal and injury crashes (crashes/3 years)	5.7	0	51
Number of rear-end crashes (crashes/3 years)	6.9	0	99
Number of sideswipe crashes (crashes/3 years)	1.9	0	31
Number of angle crashes (crashes/3 years)	3.7	0	36
Number of turning (right or left) crashes (crashes/3 years)	1.9	0	16
Number of nighttime crashes (crashes/3 years)	3.6	0	65
AADT on the mainline (vehicles/day)	37,945	10,406	93,000
AADT on the cross street (vehicles/day)	8,598	500	48,000
Indicator for intersection in Northern California (=1 if in Northern California, = 0 otherwise)	0.45	0	1
Indicator for intersection in Southern California (=1 if in Southern California, = 0 otherwise)	0.36	0	1
Indicator for intersection in Charlotte (=1 if in Charlotte, = 0 otherwise)	0.19	0	1
Number of approach corners with clearance of 50 ft or less	0.33	0	2
Number of receiving corners with clearance of 50 ft or less	0.44	0	2
Number of approach corners with clearance of 75ft or less	0.46	0	2
Number of receiving corners with clearance of 75ft or less	0.61	0	2
Number of approach corners with clearance of 100ft or less	0.64	0	2
Number of receiving corners with clearance of 100ft or less	0.79	0	2
Number of approach corners with clearance of 150 ft or less	0.90	0	2
Number of receiving corners with clearance of 150 ft or less	0.96	0	2
Number of approach corners with clearance of 250 ft or less	1.14	0	2
Number of receiving corners with clearance of 250 ft or less	1.19	0	2
Indicator for mainline with posted speed of 50 mph or more (=1 if 50 mph or higher, =0 otherwise)	0.44	0	1
Indicator for mainline with 11 ft or narrower lanes (=1 if 11 ft or narrower lanes, =0 otherwise)	0.31	0	1
Indicator for residential area (=1 for residential, =0 otherwise)	0.16	0	1
Driveway density (driveways/mile)	41.74	0	111

SAFETY PERFORMANCE FUNCTION DEVELOPMENT

The research team first generated a correlation matrix for all potential explanatory variables. The correlation between predictors was key to minimizing the negative effects of multicollinearity. Having two highly correlated variables in a model may result in erratic changes of the estimated coefficients and lead to biased model estimation results. The correlation matrix was used as guidance throughout the model specification and development process. The safety performance function development began with the simplest functional form in which only traffic volumes were included. Each potential predictor was then added to the model and the goodness of fit was evaluated.

The data for this study represent three regions: Northern California, Southern California, and the largest city in North Carolina. It is reasonable to assume that these three regions might have inherently different characteristics that can affect the safety outcomes or at least crash counts at signalized intersections. These elements could be unknown, immeasurable, or unavailable for the analyses conducted in this study. The research team tested this assumption by estimating crash prediction models using separate subsets of data from each of the three regions and comparing the model parameters. The test results revealed little difference between Northern and Southern California in this regard, so all intersections from California were considered as one group. The tests indicated larger differences between Charlotte and California sites, but the 95-percent intervals of the model parameters still overlapped. This process and its results supported the decision to analyze all intersections together as a single dataset and use an indicator to account for the inherent differences between California and Charlotte.

The research team developed crash prediction models separately for total, fatal and injury, rear-end, sideswipe, right-angle, and right and left turn crashes at signalized intersections. Combinations of clearances on both approach and receiving corners were tested. The research team decided to use corner clearance of 50 ft for all models after considering the overall model fit and the practicality of potential applications.

ANALYSIS RESULTS

Table 2 through Table 8 present the estimated CMFs and related standard errors for each of the following target crash types.

- Total: all crashes within 250 ft of intersection (all types and severity levels combined).
- Fatal and Injury: all injury crashes within 250 ft of intersection (K, A, B, and C injuries on KABCO scale).
- Rear-end: all crashes coded as “rear-end” within 250 ft of intersection.
- Sideswipe: all crashes coded as “sideswipe” within 250 ft of intersection.
- Right-angle: all crashes coded as “right-angle” within 250 ft of intersection.
- Turning: all crashes coded as “right-turn” or “left-turn” within 250 ft of intersection.

- Nighttime: all crashes with lighting condition coded as “dark”, “dawn” or “dusk” within 250 ft of intersection.

This study presents aggregate results by number of approach and receiving corners with driveways within 50 ft of the intersection. The study presents results separately for the number of approach corners (i.e., one or two) and number of receiving corners (i.e., one or two) compared to no driveways within 50 ft of the intersection on the approach or receiving corners, respectively.

For total crashes, the CMFs were 0.82 and 0.67 for corner clearance of 50 ft or less on one and two approach corners, respectively, compared to no driveways within 50 ft of both approach corners. The CMFs were 1.33 and 1.76 for corner clearance of 50 ft or less on one and two receiving corners, respectively, compared to no driveways within 50 ft of both receiving corners. All CMF estimates were statistically significant at the 95 percent confidence level.

Table 2. Results for total crashes.

Number of corner(s) with limited clearance	CMF	S.E.
1 approach corner with driveway(s) within 50 ft	0.82**	0.08
2 approach corners with driveway(s) within 50 ft	0.67**	0.13
1 receiving corner with driveway(s) within 50 ft	1.33**	0.11
2 receiving corners with driveway(s) within 50 ft	1.76**	0.30

Note: Double asterisks (**) indicate statistically significant results at the 95 percent confidence level.

For fatal and injury crashes, the CMFs were 0.79 and 0.62 for corner clearance of 50 ft or less on one and two approach corners, respectively, compared to no driveways within 50 ft of both approach corners. The CMFs were 1.29 and 1.68 for corner clearance of 50 ft or less on one and two receiving corners, respectively, compared to no driveways within 50 ft of both receiving corners. All CMF estimates were statistically significant at the 95 percent confidence level.

Table 3. Results for fatal and injury crashes.

Number of corner(s) with limited clearance	CMF	S.E.
1 approach corner with driveway(s) within 50 ft	0.79**	0.08
2 approach corners with driveway(s) within 50 ft	0.62**	0.13
1 receiving corner with driveway(s) within 50 ft	1.29**	0.11
2 receiving corners with driveway(s) within 50 ft	1.68**	0.29

Note: Double asterisks (**) indicate statistically significant results at the 95 percent confidence level.

For rear-end crashes, the CMFs were 0.79 and 0.63 for corner clearance of 50 ft or less on one and two approach corners, respectively, compared to no driveways within 50 ft of both approach corners. The CMFs were 1.36 and 1.86 for corner clearance of 50 ft or less on one and two receiving corners, respectively, compared to no driveways within 50 ft of both receiving corners. The CMF estimates were statistically significant at the 95 percent confidence level.

Table 4. Results for rear-end crashes.

Number of corner(s) with limited clearance	CMF	S.E.
1 approach corner with driveway(s) within 50 ft	0.79**	0.09
2 approach corners with driveway(s) within 50 ft	0.63**	0.15
1 receiving corner with driveway(s) within 50 ft	1.36**	0.14
2 receiving corners with driveway(s) within 50 ft	1.86**	0.38

Note: Double asterisks (**) indicate statistically significant results at the 95 percent confidence level.

For sideswipe crashes, the CMFs were 0.83 and 0.69 for corner clearance of 50 ft or less on one and two approach corners, respectively, compared to no driveways within 50 ft of both approach corners. These two CMF estimates were not statistically significant at the 90 percent confidence level. The CMFs were 1.31 and 1.71 for corner clearance of 50 ft or less on one and two receiving corners, respectively, compared to no driveways within 50 ft of both receiving corners. The CMF for one corner was statistically significant at the 95 percent confidence level and the CMF for two corners was statistically significant at the 90 percent confidence level.

Table 5. Results for sideswipe crashes.

Number of corner(s) with limited clearance	CMF	S.E.
1 approach corner with driveway(s) within 50 ft	0.83	0.12
2 approach corners with driveway(s) within 50 ft	0.69	0.19
1 receiving corner with driveway(s) within 50 ft	1.31**	0.14
2 receiving corners with driveway(s) within 50 ft	1.71*	0.38

Note: Asterisk (*) indicates statistically significant results at the 90 percent confidence level and double asterisks (**) indicate statistically significant results at the 95 percent confidence level.

For right-angle crashes, the CMFs were 1.03 and 1.06 for corner clearance of 50 ft or less on one and two approach corners, respectively, compared to no driveways within 50 ft of both approach corners. Neither CMF estimates were statistically significant at the 90 percent confidence level. The CMFs were 1.42 and 2.02 for corner clearance of 50 ft or less on one and two receiving corners, respectively, compared to no driveways within 50 ft of both receiving corners. The CMF estimate for one corner was statistically significant at the 95 percent confidence level and the CMF for two corners was statistically significant at the 90 percent confidence level.

Table 6. Results for right-angle crashes.

Number of corner(s) with limited clearance	CMF	S.E.
1 approach corner with driveway(s) within 50 ft	1.03	0.16
2 approach corners with driveway(s) within 50 ft	1.06	0.34
1 receiving corner with driveway(s) within 50 ft	1.42**	0.20
2 receiving corners with driveway(s) within 50 ft	2.02*	0.56

Note: Asterisk (*) indicates statistically significant results at the 90 percent confidence level and double asterisks (**) indicate statistically significant results at the 95 percent confidence level.

For turning (right or left turn) crashes, the CMFs are 1.00 and 1.01 for corner clearance of 50 ft or less on one and two approach corners, respectively, compared to no driveways within 50 ft of both approach corners. The CMFs are 1.22 and 1.49 for corner clearance of 50 ft or less on one and two receiving corners, respectively, compared to no driveways within 50 ft of both receiving corners. None of these CMF estimates are statistically significant at the 90 percent confidence level.

Table 7. Results for turning crashes.

Number of corner(s) with limited clearance	CMF	S.E.
1 approach corner with driveway(s) within 50 ft	1.00	0.15
2 approach corners with driveway(s) within 50 ft	1.01	0.30
1 receiving corner with driveway(s) within 50 ft	1.22	0.15
2 receiving corners with driveway(s) within 50 ft	1.49	0.36

For nighttime crashes, the CMFs were 0.94 and 0.87 for corner clearance of 50 ft or less on one and two approach corners, respectively, compared to no driveways within 50 ft of both approach corners. These two CMF estimates were not statistically significant at the 90 percent confidence level. The CMFs were 1.29 and 1.67 for corner clearance of 50 ft or less on one and two receiving corners, respectively, compared to no driveways within 50 ft of both receiving corners. The CMF estimate for one receiving corner was statistically significant at the 95 percent confidence level and the CMF for two corners was statistically significant at the 90 percent confidence level.

Table 8. Results for nighttime crashes.

Number of corner(s) with limited clearance	CMF	S.E.
1 approach corner with driveway(s) within 50 ft	0.94	0.12
2 approach corners with driveway(s) within 50 ft	0.87	0.23
1 receiving corner with driveway(s) within 50 ft	1.29**	0.13
2 receiving corners with driveway(s) within 50 ft	1.67*	0.35

Note: Asterisk (*) indicates statistically significant results at the 90 percent confidence level and double asterisks (**) indicate statistically significant results at the 95 percent confidence level.

The objective of the disaggregate analysis was to identify specific CMFs by crash type and different conditions. The analysis could also reveal those conditions under which the strategy was more effective. The research team considered several variables in the disaggregate analysis, including major and minor road traffic volume, number of lanes on the major and minor road, posted speed limit on the mainline, driveway density on the mainline, and presence of left- and right-turn lanes on the mainline. The multivariable regression models included interaction terms to investigate the potential differential effects of corner clearance with respect to the interacted variable. For example, the interaction term for major road traffic volume and number of major road approaches with driveways within 50 ft is the product of the two variables. A statistically significant interaction term would indicate an apparent differential effect of corner clearance across different traffic volumes or the other variables of interest. The analysis results indicated that none of the interaction terms was statistically significant at even an 80 percent confidence level. While these results indicated no differential effect of corner clearance, it may have been the sample size is too small to detect differential effects at the desired level of confidence.

Economic Analysis

The research team conducted an economic analysis to estimate the cost-effectiveness of changing corner clearance at mainline access points near signalized intersections. The economic analysis examined the effect on total crashes from removing mainline access points on the receiving corners of four-legged, signalized intersections within a corner clearance distance of 50 ft. Due to the cross-sectional nature of this study, and the uncertainty around the results, which is discussed further in summary section, the research team does not advocate adding access points on approaches as a crash reduction measure at this time. However, the research team expects no safety disbenefits in total crashes from keeping access points with limited corner clearance (less than 50 ft) on the mainline approach corner for an average intersection.

These results suggest that removing access on mainline receiving corners to improve corner clearance—with reasonable assumptions on cost, service life, and the value of a statistical life—can be cost effective for reducing crashes at signalized intersections with B/C ratio ranging from 161:1 to 716:1. It is important to note these results represented the change in total crashes under average conditions with several cost assumptions. The research team recommends conducting an economic analysis to determine if improving corner clearance is likely to be cost effective for specific sites where proposed projects are considered.

SUMMARY AND DISCUSSION

The objective of this study was to undertake an evaluation of the safety effects, as measured by crash frequency, of mainline corner clearance at four-legged, signalized intersections. The study compared signalized intersections with various corner clearance using data from California and Charlotte, North Carolina to examine the effects on specific crash types: total, fatal and injury, rear-end, sideswipe, right-angle, turning, and nighttime crashes. The study did not investigate the effects of corner clearance on the cross-street approaches or intersections with three legs or more than four legs.

The introduction of access points in close proximity to the intersection area increases the number of potential conflict points on the approaches. Logically, this is expected to increase crashes. The estimated CMFs indicated that more limited clearance on receiving corners was associated with increases for all crash types, based on the data included in this analysis. These increases were statistically significant at the 90 percent level or greater for total, fatal and injury, rear-end, sideswipe, right-angle, and nighttime crashes. Only the results for turning crashes were not statistically significant at the 90 percent level. For limited corner clearance on the approach corners, the results indicated statistically significant reductions in total, fatal and injury, and rear-end crashes. The results also indicated reductions in sideswipe and nighttime crashes, and increases in right-angle and turning crashes, but none of these results was statistically significant at the 90 percent level.

The CMFs for limited corner clearance on the receiving corners were consistent with expectation, indicating statistically significant increases in total, fatal and injury, rear-end, sideswipe, right-angle, and nighttime crashes. For limited corner clearance on the approach corners, the CMFs were counterintuitive, indicating statistically significant decreases in total, fatal and injury, and rear end crashes. Intuition and past research suggest that limiting corner clearance (i.e., allowing driveways) on all corners would negatively affect safety due to complex and conflicting turning movements from the traffic in, and particularly out of, driveways in close proximity to the functional area of the intersection. However, these particular CMFs in question (i.e., decreases in total, fatal and injury, and rear end crashes for limited corner clearance on the approach corners) are among the most statistically significant results derived from this evaluation. The research team proposes a number of possible explanations for these results that are counter to the general hypothesis of the study.

As shown in Table 1, rear-end crashes constitute more than half of all crashes while angle crashes account for approximately one-quarter of all crashes. The reduction in rear-end crashes likely outweigh the increase in angle crashes and leads to the overall reduction in total crashes and fatal and injury crashes for this situation. Therefore, this discussion focuses on rear-end and angle crashes. The research team proposed the following potential hypotheses:

- The reduction in rear-end crashes on the approach corners may be associated with localized congestion from vehicles turning in and out of the driveways near the approach corners of an intersection. The vehicles turning in and out of driveways may lead to an increase in driveway-related angle crashes as the CMFs indicate, although not with statistical significance. However, this reduction in operating speeds results in fewer rear-end crashes and likely fewer angle crashes within the adjacent signalized intersection, which tend to be more severe than driveway-related crashes. With a much higher proportion in overall crashes, the decrease in rear-end crashes is likely to be larger than any increase in angle collisions. This results in an overall reduction in total and fatal and injury crashes. The statistically significant driveway density coefficient in the model for rear-end crashes seems to support this hypothesis.
- After passing through the signalized intersection, vehicles may accelerate. The interactions and conflicts from the turning vehicles (in and out of the driveways) on the receiving corners are likely to result in more crashes for all crash types. The turning vehicles from the cross streets also add to the overall traffic and likelihood of conflicts on the receiving corners. The mainline AADT on the receiving corners may not reflect this added traffic from the cross street and therefore is not captured in the model.
- The overall context of the sites with limited corner clearance is responsible for the difference rather than the specific effects of corner clearance. The limited corner clearance could be a surrogate for another factor that affects safety performance that is not captured in the models. That is, those intersections with more driveways on the approaches may have more traffic and are more likely to be congested than those without driveways on the approach simply by the nature of the roadway, not because of the presence of the driveway (e.g., stores and gas stations are there to serve the heavier traffic). The context of the intersection within the corridor is difficult to control for in a cross-sectional evaluation. In this study, the research team collected and analyzed corridor characteristic data elements including driveway density (number of driveways per mile) and type of land use (residential, commercial, or mixed use). The model estimation results suggested limited or no statistically significant effects of these elements on crashes. The evaluation set out to investigate the safety effects at intersections rather than the entire corridor, and as such could not collect and include more corridor-related characteristics in the models or examine the effects on crashes along the related corridors.

Future research could explore the hypotheses proposed and discussed in this study. Crash prediction models that include operations-related factors, such as mean operating speeds, a speed profile for intersections along the mainline, or level of service would greatly improve the results in determining the safety effects of corner clearance. Controlling for these types of factors may better explain the effects of corner clearance on rear-end and angle crashes and therefore total and fatal and injury crashes. Future research could also verify the results using data from other States. The results presented in this study are based on data from California and Charlotte, North Carolina.

Readers may be able to test the hypotheses anecdotally as well. If a comparison of intersections in a jurisdiction shows that intersections with limited corner clearance are located along more congested corridors and have similar crash type distributions to the sample intersections in this study, then the reduction in rear-end crashes due to limited corner clearance on the approach is probably a result of the area type rather than the corner clearance. Therefore, improving corner clearance on mainline approaches may be less likely to increase rear-end crashes as a result. If the area type and crash type distribution do not follow with this hypothesis and the sample data, the results of this evaluation may not be as accurate when applied to those sites.

Additionally, the sample intersections used in this evaluation were not selected as a result of safety concerns due to angle crashes. In practice, potential projects are more likely to address corner clearance at intersections with a higher proportion of angle or turning crashes than represented in this study. Consequently, projects addressing approach corners may have a higher chance of reducing total crashes and yielding a higher net benefit when improving corner clearance than implied in the results of this evaluation.

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